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19 ABSTRACT (Continue on reverse if necessary and identify by block number)

These briefing charts provide an overview of the research plan for the Artificial Intelligence Measurement System (AIMS). They provide the goals and proposed implementation procedures for the major areas of inquiry--natural language understanding, machine vision, expert systems (including expert system shells), technology assessment.

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Project Report #1

# ARTIFICIAL INTELLIGENCE MEASUREMENT SYSTEM
(Briefing Charts)

Eva L. Baker

Center for Technology Assessment
UCLA Center for the Study of Evaluation

These briefing charts were used at the ONR Contractors' Meeting, Yale University, March 1987.

By

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Artificial Intelligence Measurement System
Contract Number N00014-86-K-0395

Principal Investigator: Eva L. Baker

Center for Technology Assessment
UCLA Center for the Study of Evaluation

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# ARTIFICIAL INTELLIGENCE MEASUREMENT SYSTEM

# (AIMS)

EVA BAKER, P.I.

MARCH 1987
ONR CONTRACTORS' MEETING
YALE UNIVERSITY

# BACKGROUND

ICAI FORMATIVE EVALUATION

ARI-JPL 1983-85

WEST

PROUST

## LESSONS LEARNED

1. LIGHT FOCUS ON EFFECTIVENESS IN ICAI COMMUNITY (PROUST IS AN EXCEPTION)
2. EVEN AI APPLICATIONS DEVELOPERS FOCUS ON THEORY BUILDING RATHER THAN OUTCOMES
3. NEED FOR AIMS

UCLA

CENTER FOR THE STUDY OF EVALUATION

DEPARTMENT OF COMPUTER SCIENCE

# HELP FROM:

EDUCATIONAL TESTING SERVICE

AIR FORCE HUMAN RESOURCES LABORATORY

NAVY PERSONNEL RESEARCH AND DEVELOPMENT CENTER

NAVAL OCEAN SYSTEMS CENTER

PERCEPTRONICS

UNIVERSITY OF ILLINOIS

CONSULTANTS ROUND THE WORLD

## PROJECT SLOGAN:

## HOW SMART ARE SMART COMPUTER SYSTEMS?

# GOAL:

- TO DESCRIBE THE EFFECTIVENESS OF AI APPLICATIONS IN MULTIPLE TERMS

- TO DEVELOP AND TEST APPROACHES TO USING HUMAN BENCHMARKS

- AVOID OVERLY SIMPLIFIED ANSWERS
- WE ARE NOT LOOKING FOR A SINGLE NUMBER OR SINGLE CRITERION

## PROJECT INSPIRATIONAL MESSAGE:

ASK NOT WHAT COMPUTER SCIENCE CAN DO

FOR MEASUREMENT . . .

# APPROACH

## MULTIPLE CHARACTERIZATION OF EFFECTIVENESS OF AI IMPLEMENTATIONS

1. PLACE IN THE SCHEME OF THINGS
2. PROCESS ANALYSIS
3. OUTCOMES COMPARED TO PEOPLE ON TESTBED DOMAINS
4. COMPARATIVE SCALES

COMMON TECHNICAL APPROACH FOR NATURAL LANGUAGE AND VISION*

SEPARATE APPROACHES FOR EXPERT SYSTEMS SHELLS AND TECHNOLOGY ASSESSMENT

*WITH IMPORTANT DIFFERENCES TO BE DESCRIBED ANON

# RESEARCH AREAS

NATURAL LANGUAGE UNDERSTANDING

VISION

EXPERT SYSTEM SHELLS

APPROACHES TO TECHNOLOGY ASSESSMENT

# CONCEPTUAL ANALYSIS APPROACH*

- MAP AREA
- REVIEW AND AMEND FRAMEWORK FOR MAP
- FILL IN EXAMPLES
- REVIEW IN TERMS OF HUMAN PERFORMANCE
- ANALYZE DIFFERENCES, AREAS FOR PROGRESS, RESEARCH FUTURES, ETC.

*ORDER OF STEPS WILL DIFFER FOR NATURAL LANGUAGE AND VISION

# COMMON TECHNICAL APPROACH IN NATURAL LANGUAGE AND VISION

1. CONCEPTUAL ANALYSIS OF AREA
2. DEVELOP AND REFINE PROCESS CRITERIA FOR ASSESSING IMPLEMENTATIONS
3. REFINEMENT OF BENCHMARKING MODEL
4. CONDUCT STUDY OF PARTICULAR IMPLEMENTATIONS

# BENCHMARK APPROACH

TO DESCRIBE IMPLEMENTATION'S EFFECTIVENESS IN TERMS OF EMPIRICAL HUMAN PERFORMANCE MEASUREMENT

- DEPENDS UPON USING A DOMAIN REFERENCED ACHIEVEMENT TEST MODEL
- DEPENDS UPON CHARACTERIZING COMPUTER PERFORMANCE IN TERMS OF AN IDENTIFIABLE POPULATION, E.G., 4TH GRADE KIDS, PEOPLE WITH A 50% SIGHT LOSS

# PROCESS ANALYSIS CRITERIA
## (HIGHLIGHTS THEREOF)

- **DESIGN GOALS AND FUNCTIONAL SPECIFICATION**
  (PROBLEMS, APPROPRIATENESS, INTERFACE, CONSTRAINTS)

- **COGNITIVE PROCESS MODEL**
  (ASSUMPTIONS, SUFFICIENCY, PARSIMONY, RESEARCH BASE)

- **IMPLEMENTATION**
  (PARTS COMPLETED, LEVEL, ALGORITHMS, EASE OF EVALUATION AND MAINTENANCE, GENERALIZABILITY, ADAPTABILITY, HARDWARE, SOFTWARE REQUIREMENTS)

# PERFORMANCE BENCHMARKING

- TASKS SOLVED BY COMPUTER ANALYZED INTO PARTICULAR DOMAINS
- SPECIFICATIONS FOR "TEST" ITEMS CREATED BASED UPON THESE DOMAINS
- "ITEMS" FOUND (ETS) OR CREATED
- PEOPLE BRACKET TESTED UNTIL APPROPRIATE POPULATIONS FOUND
- IMPLEMENTATION CHARACTERIZED IN TERMS OF POPULATION PERFORMANCE

# HOW HUMAN PERFORMANCE BENCHMARKING WILL WORK

# HARD STUFF

- DEALING WITH CONSTRICTED DOMAINS (RELIABILITY)
- FINDING A COMMON BASIS FOR SCALING ACROSS DOMAINS OR AI IMPLEMENTATIONS WITHIN AREA

# OVERVIEW OF THE NATURAL LANGUAGE AREA

# NATURAL LANGUAGE SOURCEBOOK AND DATABASE

- ONLINE DATABASE QUERY/RETRIEVAL SYSTEM
- HARDCOPY VERSION OF DATABASE
- REFERENCE SOURCE OF ISSUES AND PROBLEMS IN COMPUTATIONAL ANALYSIS OF NATURAL LANGUAGE

# NATURAL LANGUAGE
# CONCEPTUAL ANALYSIS

TO BE BASED ON A SOURCEBOOK (BOTTOM-UP)

. . . DYER'S GROUP

PROCESS ANALYSES OF IMPLEMENTATIONS

. . . DYER'S GROUP PLUS HELP

HUMAN BENCHMARKS

. . . BAKER'S GROUP

# USES OF NATURAL LANGUAGE SOURCEBOOK/DATABASE

- REFERENCE SOURCE FOR NL RESEARCHERS, STUDENTS, USERS
- MECHANISM FOR AUTOMATICALLY TESTING LANGUAGE ANALYZERS
- BENCHMARK CRITERIA FOR MEASURING CAPABILITIES OF LANGUAGE PROCESSING SYSTEMS

# CONTENTS OF NATURAL LANGUAGE SOURCEBOOK/DATABASE

- COMPENDIUM OF EXEMPLARS WHICH HAVE RAISED QUESTIONS FOR AI/NLP RESEARCHERS RESEARCHERS AND LINGUISTS
- DISCUSSION OF ISSUES RAISED BY EACH EXEMPLAR
- BIBLIOGRAPHIC REFERENCES FOR EACH EXEMPLAR
- CROSS REFERENCES TO ANALYZERS WHICH CLAIM TO DEAL WITH EXAMPLES

# TECHNICAL APPROACH:

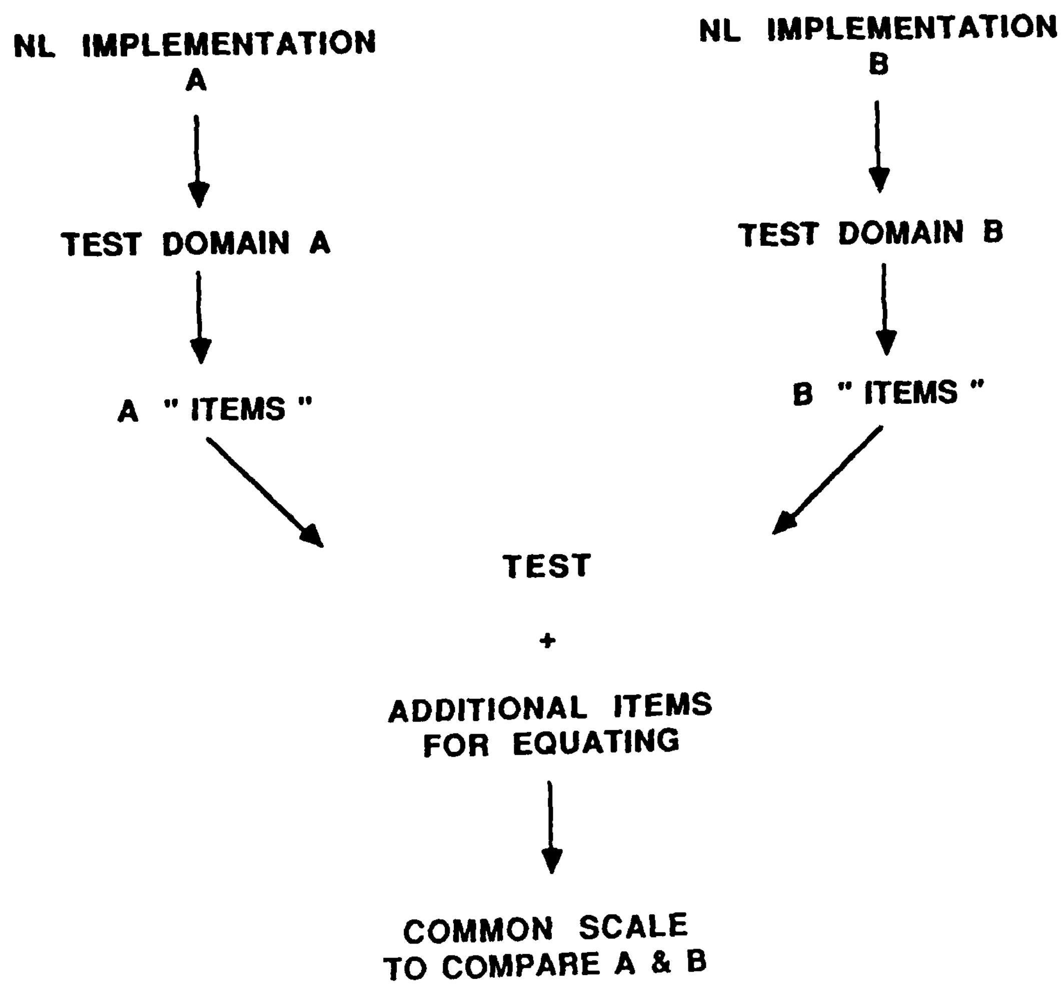
- THE PROCESS ANALYSIS OF IRUS
- IRUS AS IMPLEMENTED IN A PARTICULAR DOMAIN

# NATURAL LANGUAGE IMPLEMENTATION TO BE STUDIED FOR PROCESS ANALYSES AND BENCHMARKING

## IRUS

IRUS STANDS FOR INFORMATION RETRIEVAL USING THE RUS PARSER

## BENCHMARK COMPARISON EXAMPLE



# BENEFITS OF IRUS

- REPRESENTS COMMON APPLICATION: NL FRONT-END TO A DATABASE
- HELP FROM THE GOVERNMENT IN GETTING ACCESS

# IRUS QUERY EXAMPLES

- HOW MANY PEOPLE IN DEPT. 45 DON'T LIVE IN CAMBRIDGE OR BOSTON? LIST THEIR NAMES.

- HAS EVERY WOMAN IN DEPT. 45 WRITTEN A PAPER SINCE 1979?

(FROM BATES, MOSTER, STALLARD, BBN, 1984)

# PROBLEMS WITH IRUS

- FRONT-END TO A DATABASE
- ASSESSMENT MUST DISENTANGLE UNDERSTANDING FROM DATABASE FUNCTIONS
- IRUS IS ABOUT TO BE REDONE

## IRUS IN A PARTICULAR DOMAIN

# *FRESH*

# INTERESTING FACTS ABOUT FRESH INFLUENCING OUR ANALYSES

FRESH USES NL MENU

FRESH IS ALSO TOP SECRET

IRUS IN THE FRESH CONTEXT WILL BE ASSESSED USING HELP FROM

NOSC

NPRDC

AFHRL

# EXPERT SYSTEM SHELL AREA

- EARLY PLANNING STAGE
- EVALUATION QUESTIONS
- TECHNICAL APPROACH

# PRELIMINARY EVALUATION QUESTIONS FOR EXPERT SYSTEM SHELLS

1. HOW USEFUL IS THE TOOL IN THIS DOMAIN?
   (FACILITY, TIME, EXPERTISE, EFFICIENCY)

2. HOW WELL DOES THE TOOL FACILITATE THE INTEGRATION OF NEW KNOWLEDGE IN THE DOMAIN?
   (ADD, AMEND, REFINE, CONSISTENCY)

3. HOW WELL SUITED IS THE KNOWLEDGE REPRESENTATION FOR TESTBED DOMAINS?
   (ADAPTABILITY, UNDERSTANDABLE, COMPLETNESS, CONCISION)

4. GIVEN REQUIREMENTS, CONSTRAINTS, OUTPUT, HOW DO CURVES OF PERFORMANCE VARY?
   (BY APPLICATION, EXPERTISE, ETC.)

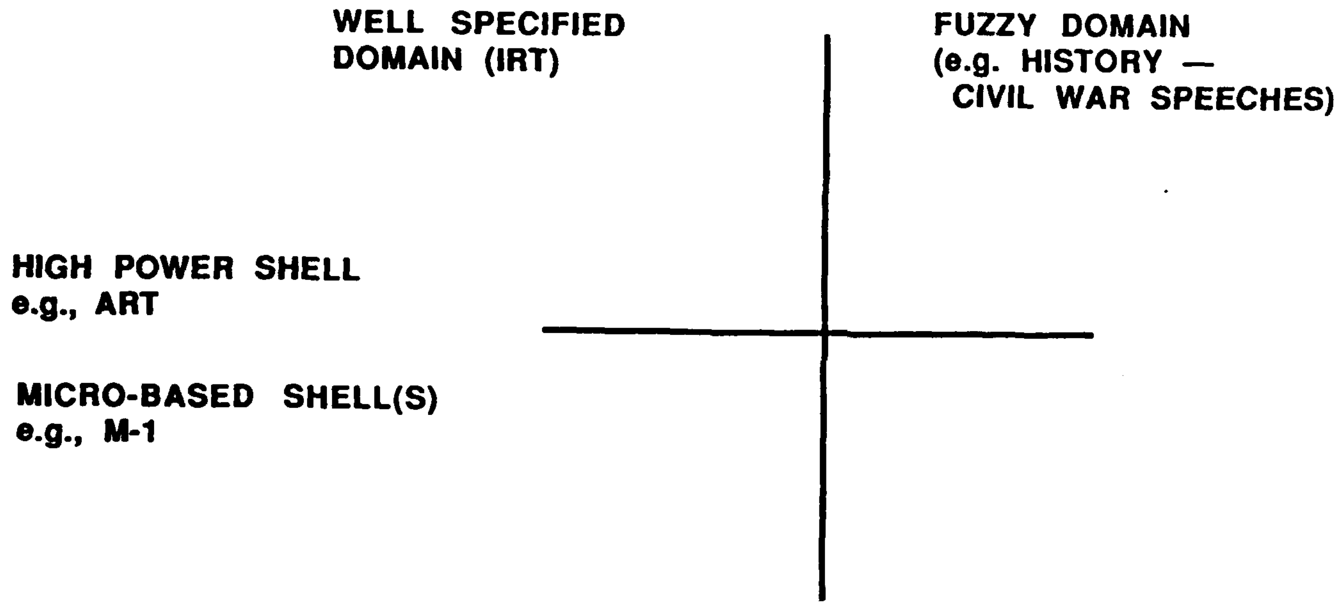
# TECHNICAL APPROACH FOR EXPERT SYSTEM SHELL AREA

DETAILED CASE STUDIES OF EXISTING SHELLS ON STANDARD TESTBED PROBLEMS

PROTOCOL ANALYSES

OUTCOMES:

- CREATION OF TESTBED PROBLEMS
- ANALYSES OF ESS IN TWO TOPIC AREAS
- REPORTS OF TIME, COST, AND EFFECTIVENESS OF THE PARTICULAR SHELLS EXAMINED
- EXAMINATION OF UTILITY OF TESTBED PROBLEMS FOR FUTURE BENCHMARKING
- DECISION TO EXTEND APPROACH TO LARGER SCALE EXPERIMENTS


WELL SPECIFIED
DOMAIN (IRT)
FUZZY DOMAIN
(e.g. HISTORY —
CIVIL WAR SPEECHES)
HIGH POWER SHELL
e.g., ART
MICRO-BASED SHELL(S)
e.g., M-1

# PROTOCOL ANALYSIS FOR EXPERT SYSTEM SHELL AREA

- TO DETERMINE RATE AND PROGRESS ON PROTOTYPE APPLICATION
- TO DETERMINE ENABLING AND DISABLING FACTORS AT EACH STAGE
- TO DETERMINE FUNCTIONAL TASK REQUIREMENTS
- USING OBSERVATION (VIDEO) AND INTERVIEW

# SPIN-OFF USE OF ESS TESTBED DOMAINS
# ( IRT + SPEECHES )

- AI TEST DEVELOPER

- DEVELOPMENT OF MEASURES FOR "DEEP UNDERSTANDING" TASKS

- SUPPORTED BY OERI

# TECHNOLOGY ASSESSMENT AREA

QUESTIONS:

WHAT APPROACHES IN COMMON?

WHAT LESSONS LEARNED?

REQUIREMENT:

COMMON DOCUMENTATION ACROSS ALL THE THREE PROBLEM AREAS (NL, VISION, ESS)

CONFERENCE:

# PRODUCTS

1. CONCEPTUAL ANALYSES (OR MAPS) OF HUMAN PERFORMANCE TASKS AND COMPUTER TASKS FOR NLP AND VISION

2. REPORTS OF SPECIFIC IMPLEMENTATIONS IN NLP AND VISION

3. MODEL FOR HUMAN BENCHMARKING IN APPLICATION AREAS WITH SPECIFIC EXAMPLES IN NLP AND VISION

4. EXPERT SYSTEM SHELL CASE STUDIES

5. LESSONS LEARNED DOCUMENT ON TECHNOLOGY ASSESSMENT

# CSE STAFF ON THE AIMS PROJECT

EVA BAKER
ELAINE LINDHEIM
RICH SHAVELSON
MERL WITTROCK
BENGT MUTHEN
DEAN SLAWSON

# NATURAL LANGUAGE

MICHAEL DYER
ALEX QUILICI
JOHN REEVES
RIC FEIFER

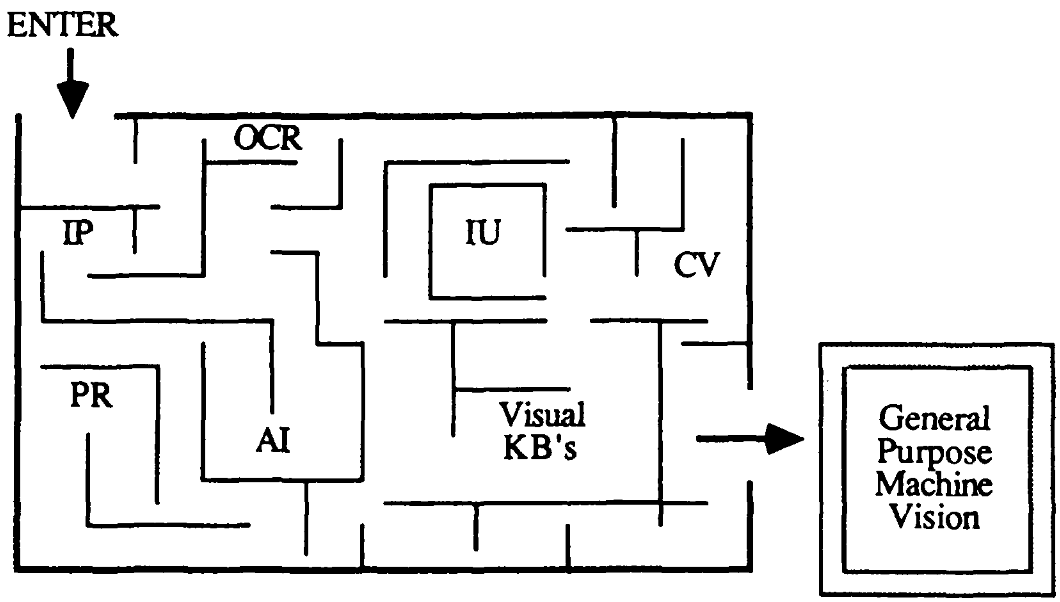
## VISION

JOSEF SKRZYPEK
DAVID GUNGNER
EDMOND MESROBIAN
EUGENE PAIK
MICHAEL STIBER

AND A CAST OF THOUSANDS AS CONSULTANTS

MANAGEMENT HELP: JOAN HERMAN
KATHARINE FRY

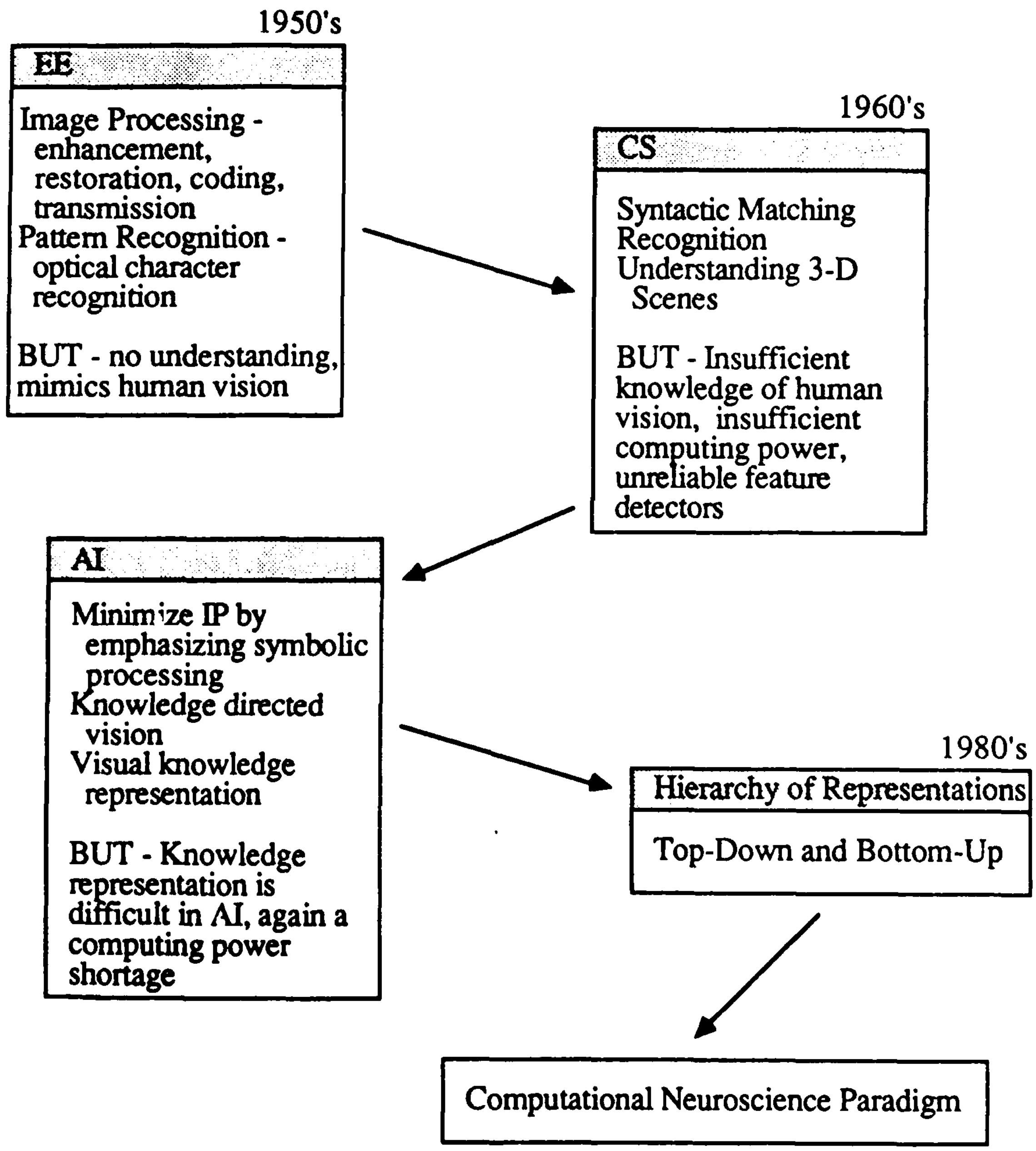
# WHICH WAY DO WE GO?



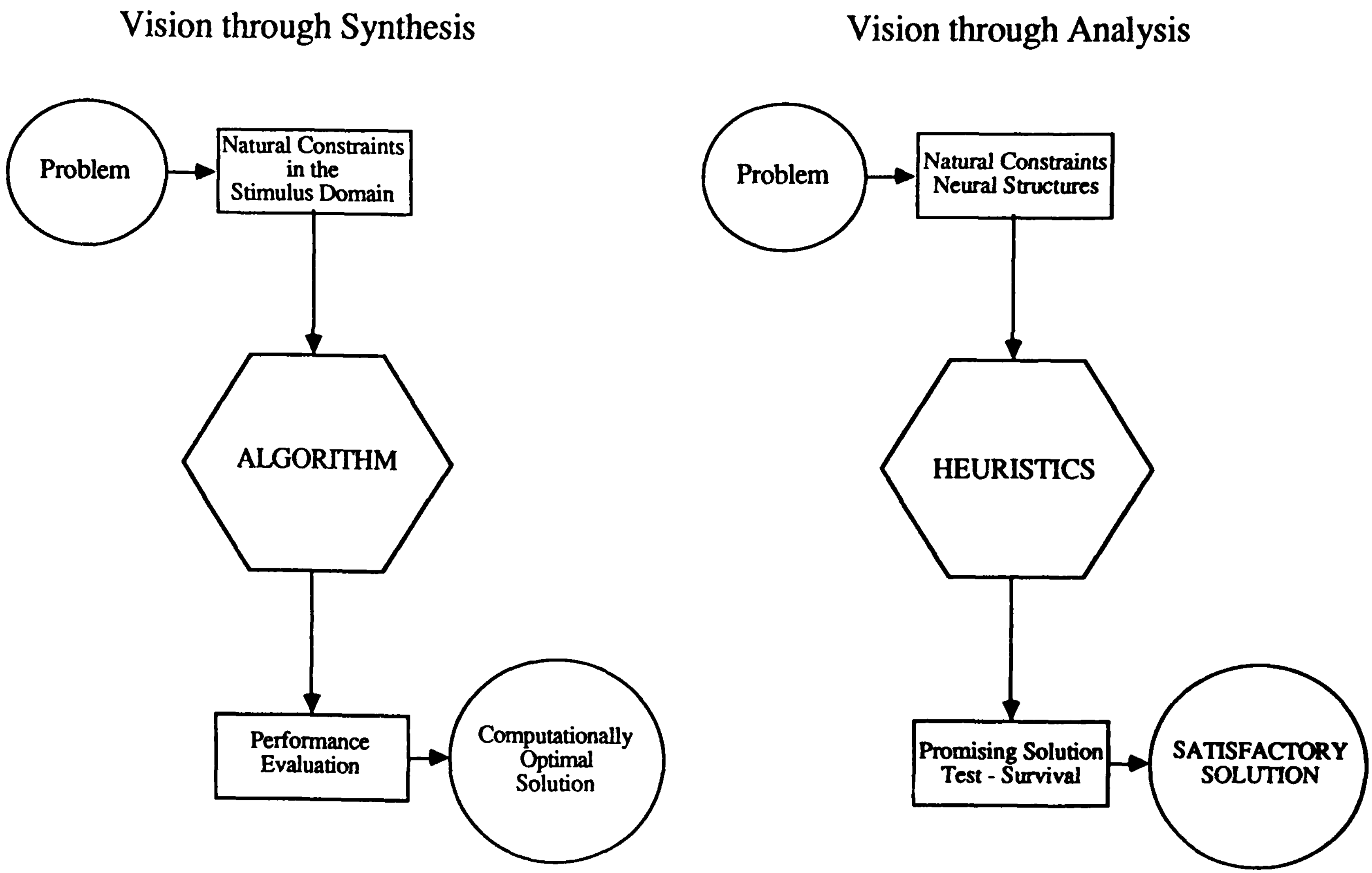
# CATEGORIES OF PROCESSING

| | |
|---|---|
| Processing | VP = Video Processing<br>IP = Image Processing<br>PP = Picture Processing |
| Classification | PR = Pattern Recognition<br>II = Image Interpretation |
| Understanding | SA = Scene Analysis<br>IU = Image Understanding<br>CV = Computer Vision |

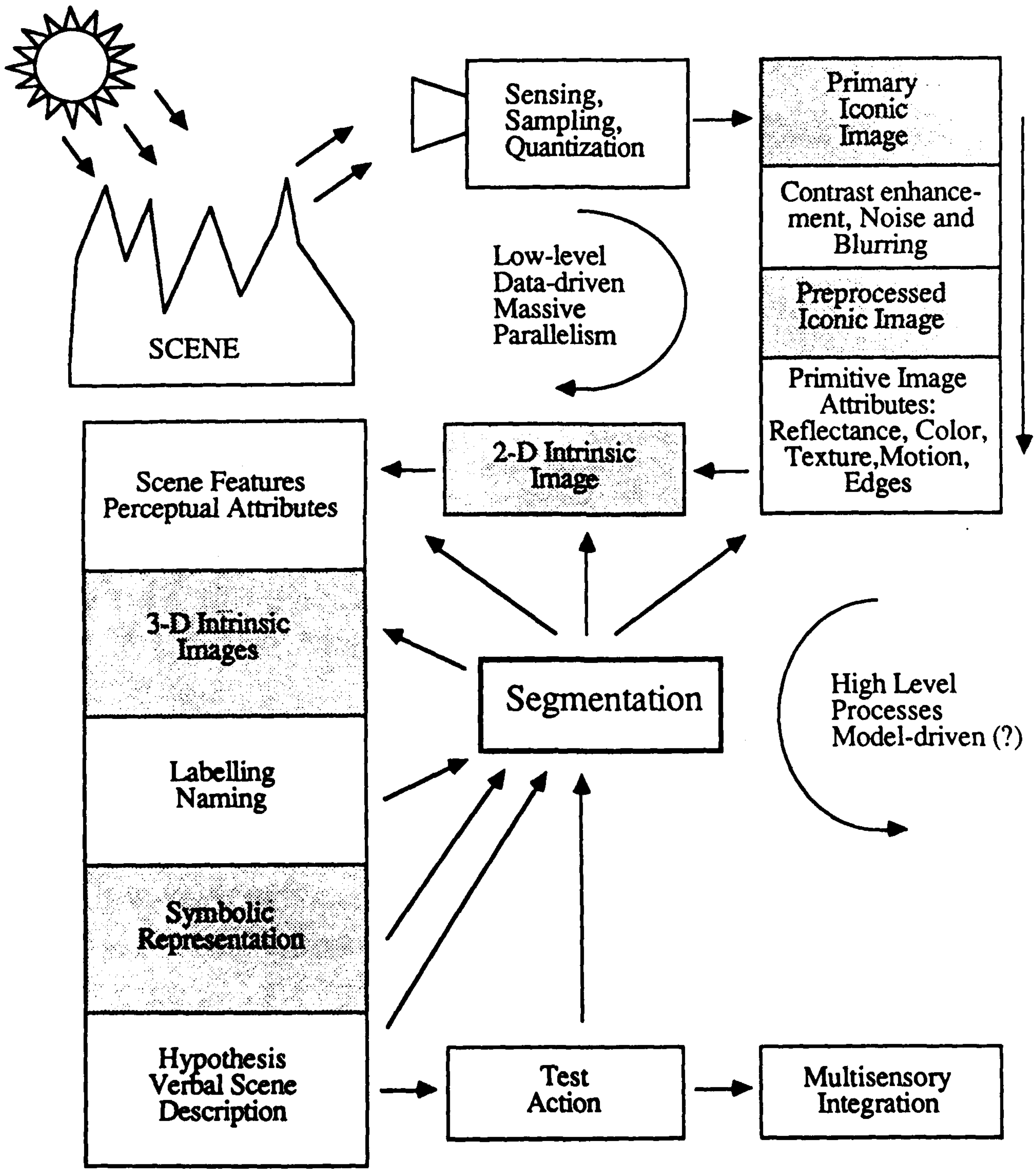
# A HISTORY OF COMPUTER VISION



## APPROACHES TO VISION

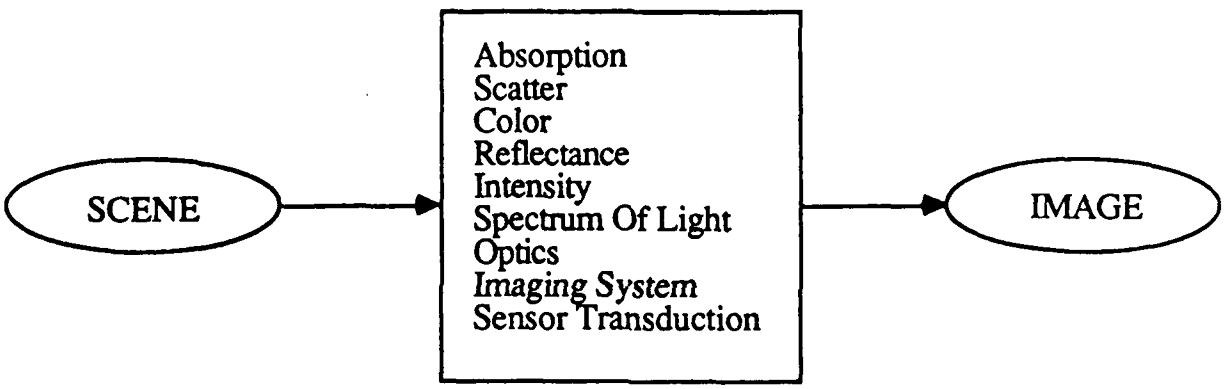


## REPRESENTATIONAL SCHEME OF MACHINE VISION



# COMPUTER VISION - THE BASIC PROBLEM

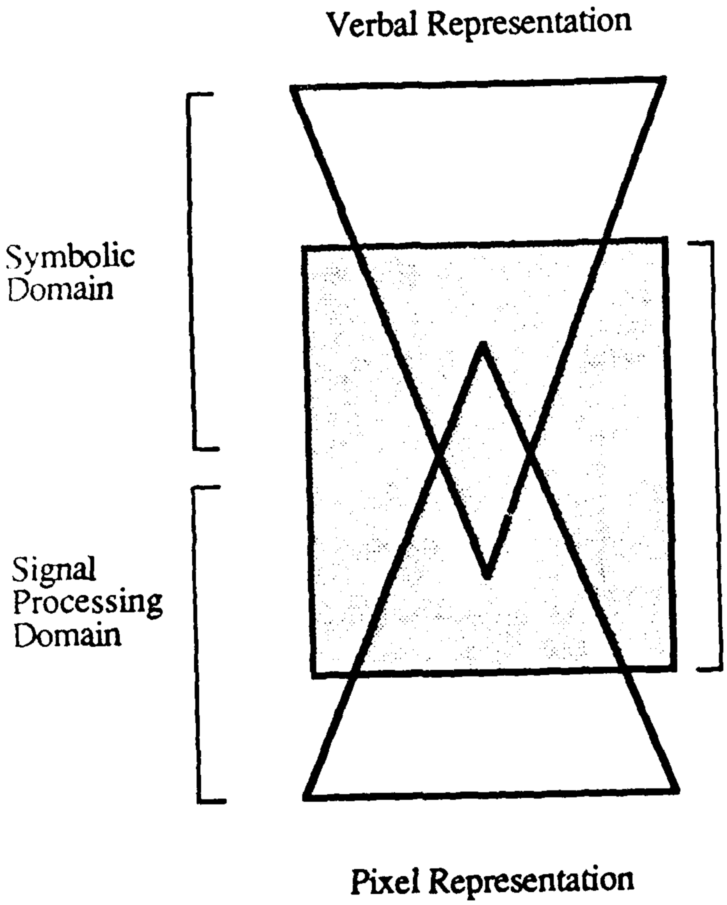
- Information is lost during image formation
- Inverse mapping from images to scenes is not unique




- Image understanding is difficult because we do not understand how the various confounding processes interact in the resulting image

- Image understanding is difficult because we do not understand understanding

# THE SEGMENTATION PROBLEM




Segmentation

- partition the image into meaningful regions

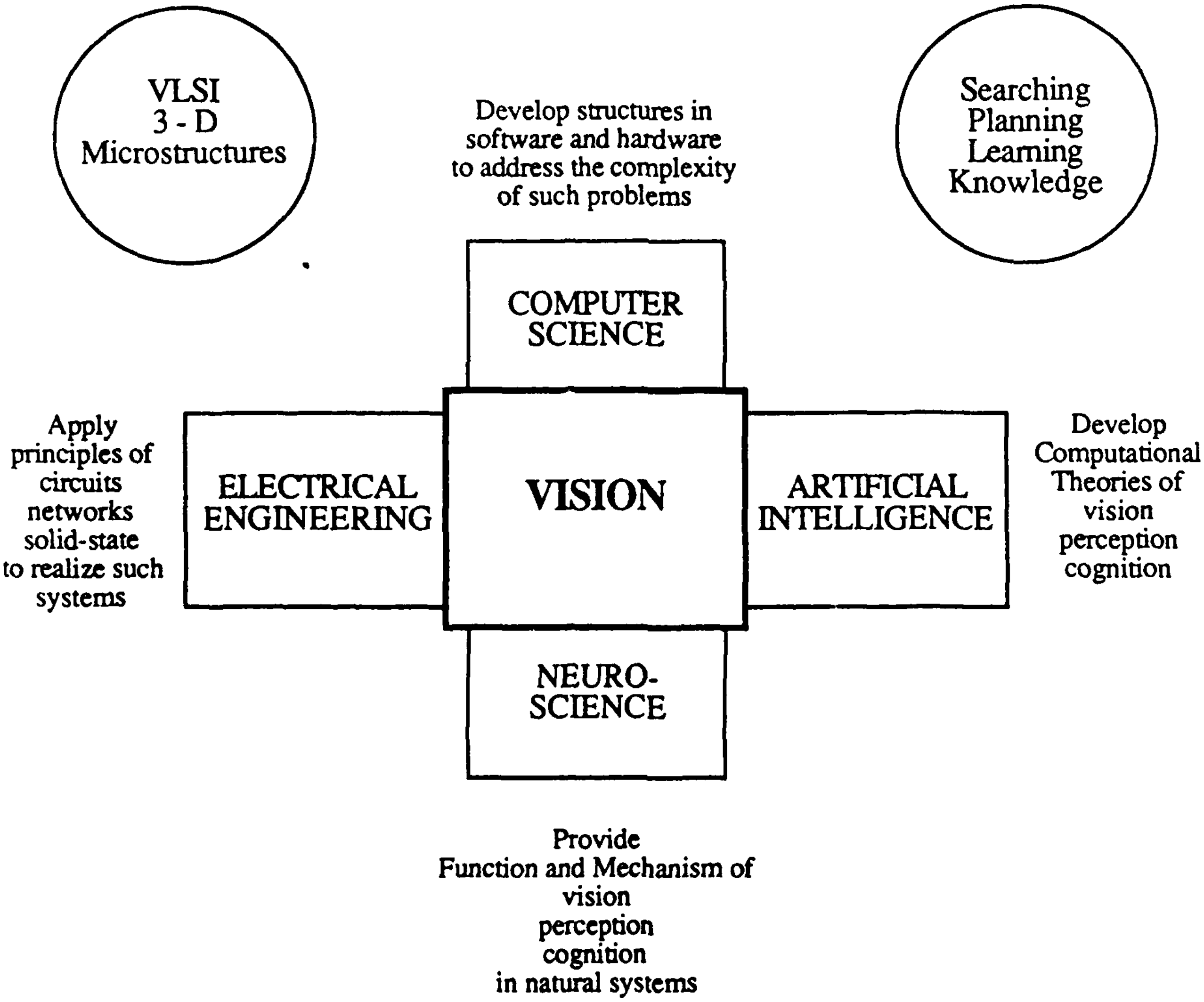
- regions are 2D groupings of elements or features based on: similarity, proximity, threshold

Segmentation is difficult

- Conceptually
  Data driven?
  Knowledge driven?
  Both?

- Computationally
  Transition in the data structure from intensity to symbols

# VISION MUST BE INTERDISCIPLINARY



# COMPUTATIONAL NEUROSCIENCE

## ASSUMPTIONS

*BRAIN = information processsing system*

*known properties of neurons can be simulated with available technology*

*information processing capabilities of neural system do not involve super-natural principles (monism - dualism)*

## REDUCTIONIST VIEW

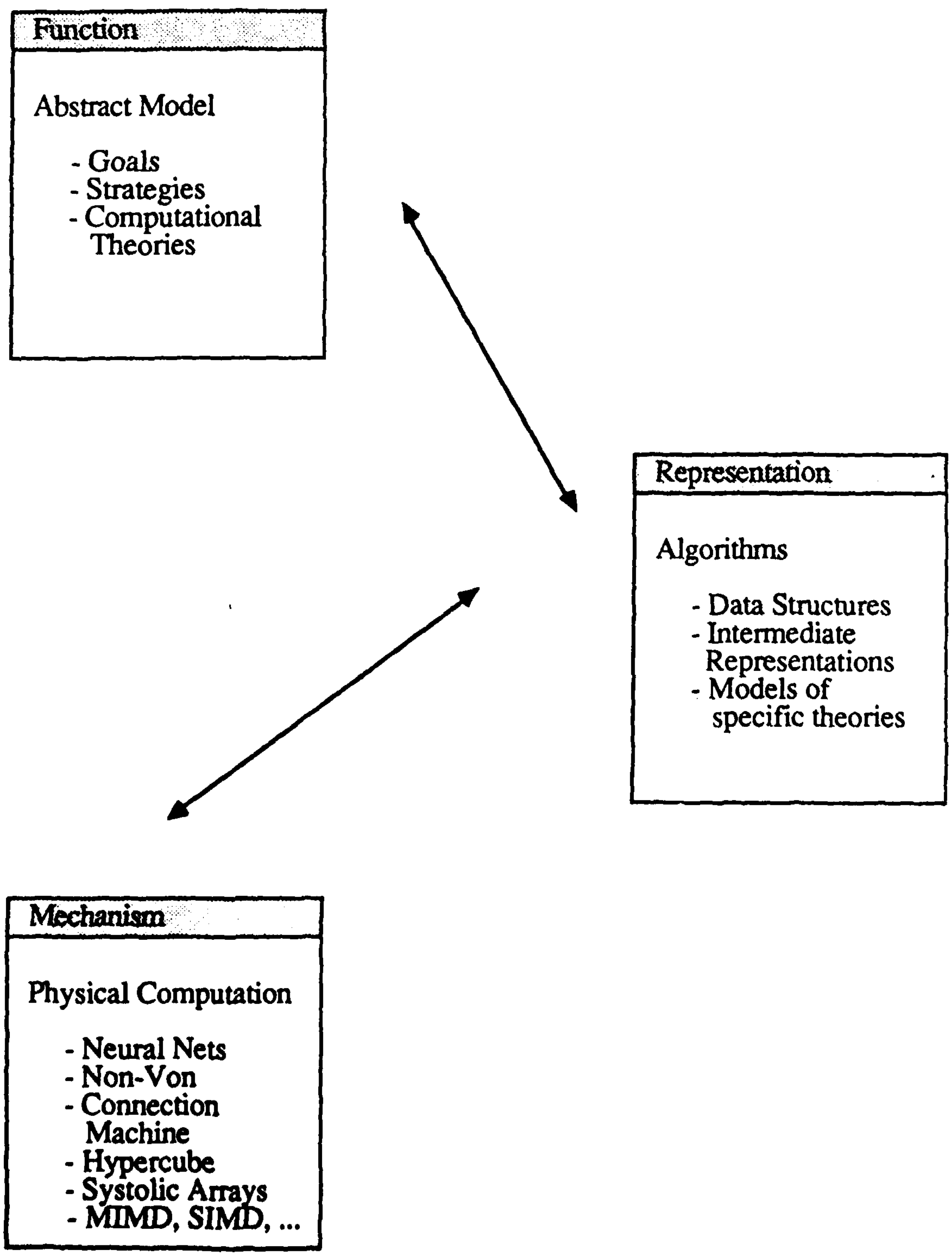
Essential features of brain functions are based on:

CONNECTIVITY

SIGNAL PROCESSING

NETWORK PLASTICITY

## COMPUTATIONAL NEUROSCIENCE VIEW OF IMAGE UNDERSTANDING



# REAL TIME REQUIREMENTS

Perception has real time constraints

Current realizations of machine perception are slow

## Need New Approach -

dedicated parallel architectures and distributed computation

## Implication -

INSEPARABILITY OF STRUCTURE AND FUNCTION

# WHAT ABOUT PREVIOUS WORK?

- DO THEY REALLY WORK?
- HOW WELL?
- IN WHAT DOMAINS?

DON'T KNOW -

Because to evaluate machine vision systems is
to know what vision is.

CATCH - 22

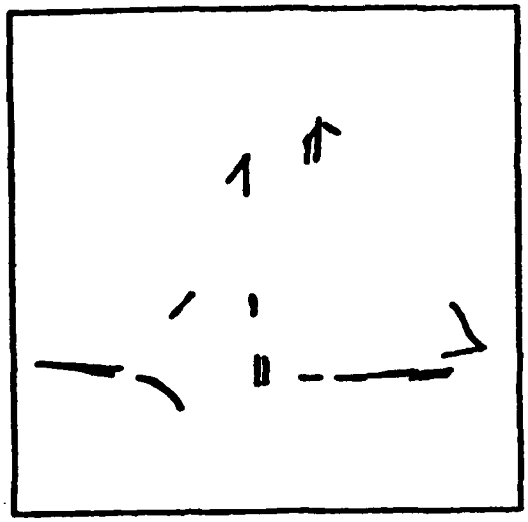
# OUR APPROACH

Human Visual Task Performance ⟷ Evaluating Performance of Machine Vision

Need tasks that meaningfully compare human

and machine vision

# GESTALT CLOSURE TEST

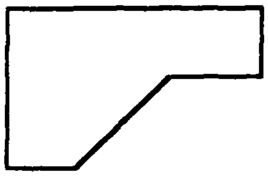
 

- Segmentation task
- Incomplete data to match against a model

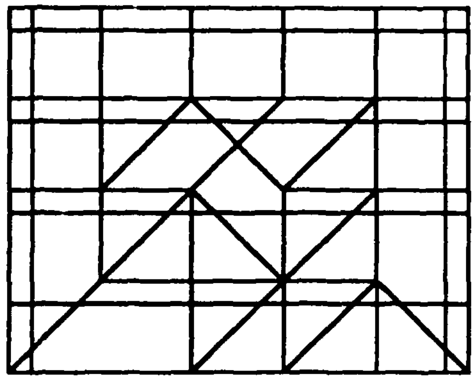
What is the model?

How much data is needed?

# HIDDEN FIGURES TEST



FIND
THIS
FIGURE

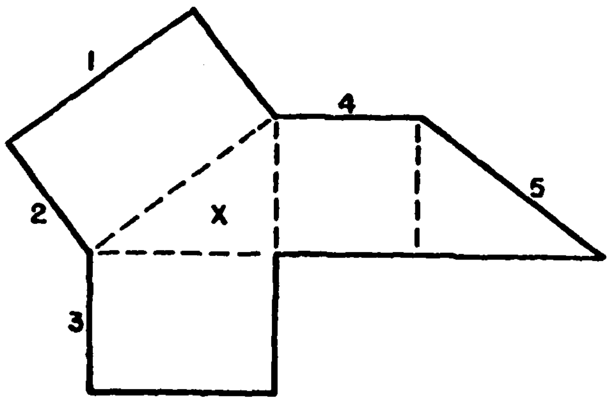


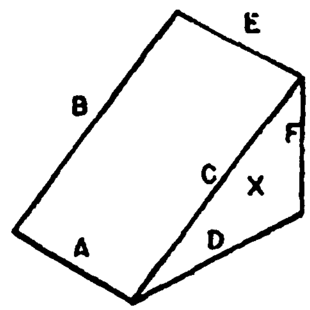
IN THIS DRAWING

- Hard for people, easy for machines
- Not an appropriate visual task for comparison
  comparison and evaluation

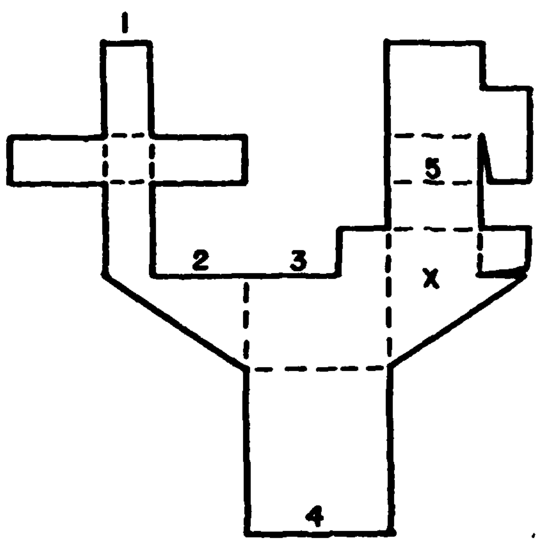
# SURFACE TESTS

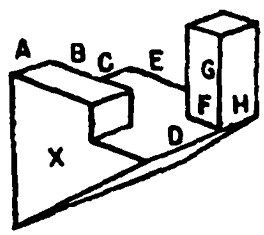
Some are easy:




Some are hard:




- Rotation and manipulation of internal models
- Easier ones can be solved by labelling techniques
- Harder ones require ?

# CONCLUSION

- New approaches needed for machine vision

- How do you evaluate current and future systems?

- Develop evaluation model based on human visual performance